VISIBILITY OF COLORED TARGETS IN FREE-SWIMMING SCUBA SEARCH

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INTRODUCTION

In a series of previous studies, the visibility in the water of targets painted with various colors and types of paint has been investigated both in natural[1] and artificial light.[2] These studies were carried out under a variety of conditions in many different bodies of water, but one aspect of these studies was always the same: the targets were always in a clearly specified location. The divers knew where the targets would be positioned and had only to report their color when they were visible.

In this study, the visibility of various paints and colors was tested under conditions comparable to what might be found in underwater search; targets were randomly scattered on the bottom of a small, shallow (10 ft deep) pond, and free swimming SCUBA divers were allowed a limited period of time in which to find as many of them as possible.

METHOD

The study was carried out in a roughly elliptical pond whose axes were approximately 150 and 200 ft. The maximum depth was 10 feet. The bottom was covered with a fine, light brown silt which supported some scrubby vegetation. The water was moderately clear when the silt was settled. Underwater visibility was about 15 - 20 feet. An area about 100 feet square was measured and buoys placed at each of the four corners. The targets were positioned randomly on the bottom of this area.

The targets were plastic disks, 8.5 inches in diameter, with pieces of lead, 2 inches square, bolted to the center of each disk. These assemblies were painted either yellow, silver, white, black, half white-half black, or fluorescent orange. The divers were not shown sample disks before the search began but were told only that they were 8" disks painted different colors. The number of targets of each color ranged from 9 to 15 on a given trial.

The subjects were the graduating class of Navy SCUBA divers at the Naval Submarine Base and their instructors.

The procedure was as follows. The first run was carried out in clear water, before any silt had been stirred up. Two of the diving instructors searched the area once and recovered as many targets as possible within a 15-minute period.

The second run was carried out immediately afterwards. The clarity of the water was now reduced by the silt which had been stirred up by the first run. The recovered targets were replaced again in a random arrangement, and the instructors repeated their search.

The third run was carried out three weeks later, with the graduates of the SCUBA class as subjects. The class of 16 was divided in half. The first half swam across the pond in order to stir up the silt and decrease the visibility in the water. They were followed immediately by the second group, who were instructed to retrieve only those targets which they could actually see.

All three runs were carried out around midday on sunny days.

RESULTS

Table I gives the percentages of disks of each color recovered on each of the runs and the mean recovery for the three runs. On the average, fluorescent orange was most visible; silver, white and the disk which was half white were of intermediate visibility, whereas the yellow and black disks were least visible. The poor recovery rate for the yellow disk was unexpected, but it occurred on each of the three trials.

Table I. Percentage of target disks of various colors recovered on each run

	Color of Disk					
Run	Orange	Yellow	White	Silver	Black	Black/White
1.	100	80	100	90	80	92
2.	64	50	78	70	60	92
3.	57	20	25	46	14	27
Mean	74	50	68	69	51	70

DISCUSSION

Previous work (Kinney et al. 1967) has shown that in sunlit, turbid water, the most visible colors are the longer wavelengths and white. Fluorescent orange and white were therefore expected to be the most visible, and, indeed, these two colors, in addition to silver, were retrieved the most on the average. Black was one of the two colors least retrieved. This much conforms perfectly with predictions from previous studies.

One aspect of the results, however, was unexpected. Few of the yellow disks were retrieved on each of the three trials. This suggests that the yellow was a good match for the sandy bottom and also probably formed a poor contrast with the suspended silt. The black, on the other hand, either blended with the dark patches of vegetation or was simply too dark to be seen.

It was worth noting that the divers reported that visibility was so poor on

the third run that they believed they were recovering the disks largely by feel rather than sight. No doubt the divers stumbled on some of the disks by feel - although they were specifically instructed not to search this way - but the great similarity of the results on the third trial with those on the first two trials strongly suggests that vision was in fact the dominant sense. If the disks were found largely by touch, there would be no reason for the white, silver and fluorescent orange disks to have been recovered in the largest numbers.

These results, in summary, are a good example of the usefulness of evaluating experimental predictions in an operational experiment. Such trials indicate which experimental results hold up dependably. They also demonstrate how small, unforeseen details can lead to a failure in the predictions. In general, these results indicate that previous findings as to which colors have greater or lesser visibility under water can be verified in underwater search situations. This requires however that details of the specific location such as water clarity, atmospheric conditions, bottom quality and dimensions of underwater operational locale be considered.

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13. ABSTRACT

SCUBA divers searched a lake bed for randomly-positioned targets painted with various colors. The percentage of each color retrieved was tabulated. Results conformed to predictions based on the results of previous highly controlled experiments and show that these data have practical application in underwater search situations.

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